To this difference must be added the many unique advantages of the Home Hospital method such as: (1) The directness of its attack upon the home conditions as a crucial, underlying cause of tuberculosis and its consequent poverty; (2) the readiness with which unsuspected, incipient cases may be detected and checked; (3) the exceptional opportunity it affords for adequate control of the disease and family; (4) its avoidance of the opposition, deterrent influence, worry, and other hardships inevitably occasioned by the separation of the sick from the well members of the family; (5) its preservation of the integrity of the home; (6) its care of classes of patients who either could not or would not go to institutions; (7) its fostering an increase of earning capacity in the wage earner and a gradual return to normal conditions; (8) its provision against a return of either the patient or family to the inimical environment where the disease was contracted and is likely to recur; and (9) its care not only for the physical but for the economic and social ills not merely of the patient but of the entire family.

Such a work aims at causes; seeks not only the cure of the individual but the protection of society; is concerned with the patient, his family, and environment, and deals with fundamental questions of livelihood and of life.

SEWAGE DISINFECTION

FOR VESSELS AND RAILWAY COACHES.

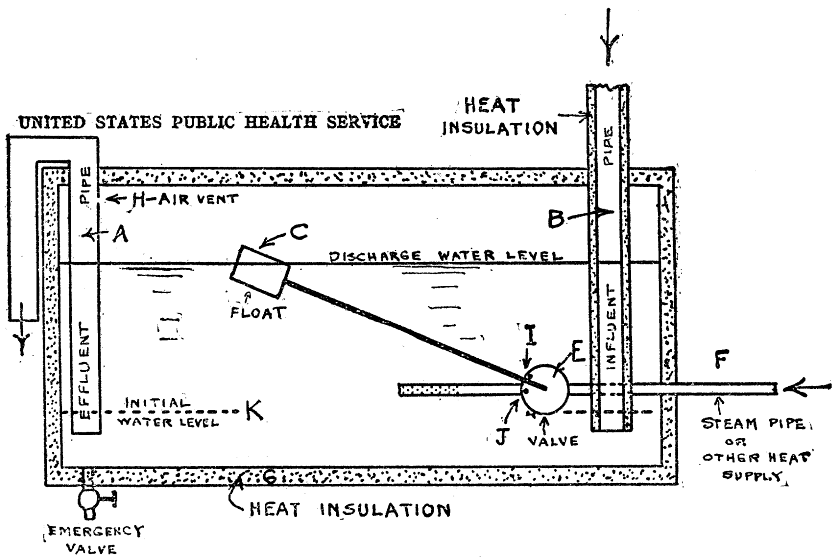
By LESLIE C. FRANK, Sanitary Engineer, United States Public Health Service.

The desirability of disinfecting the sewage of vessels traveling in lanes as heavily frequented as those on the Great Lakes system has been emphasized by the studies of De Valin (Reprint No. 168 from the Public Health Reports), and of the International Joint Commission on Boundary Waters. In these lanes of fresh-water travel, within a very short time after one steamer has discharged toilet wastes another steamer will pass over the same spot and may take in drinking water. Furthermore, these lanes of travel pass close by the drinking-water intakes of a number of large cities. The present situation with regard to railways passing over watershed areas is even more serious. The dangers of disease infection due to these conditions need no comment.

In March of this year Prof. Earle B. Phelps suggested that steam might be used to disinfect the sewage from steamers and railway coaches before it is discharged. The following device has been designed by the writer to perform this function automatically.

Description.

The device is composed of: A chamber G insulated by some heat-insulating material such as the common magnesia cement, or sawdust; an influent pipe B penetrating nearly to the bottom of the tank; an effluent pipe A penetrating nearly to the bottom of the tank, and perforated at some point H near the top of the tank by a small hole about one-eighth inch in diameter; a steam pipe F provided with an ordinary straightway valve E and a float C. The lever handle of the straightway valve has been removed and replaced by a disk, at the center of which is freely pivoted the lever arm of the float C, and which disk is provided with two pins I and J.



Operation.

The operation of this device is as follows: Assume that the initial water level in the tank is at K. The steam valve E is in its closed position and the influent pipe B is submerged below the water level; in other words, the influent pipe B is always trapped, even at the times of minimum water level in the tank. The entrance of sewage into the tank through B causes the level of the water in the tank to rise gradually and to carry the float upward with it. The float arm, however, is pivoted freely upon the steam-valve disk and therefore does not turn on the steam by revolving the disk until it engages the pin I; that is, until the liquid in the tank has reached a certain predetermined height, dependent upon the position of the pin I. When this height of water is reached the steam is gradually turned on. For

a time the entering steam is immediately condensed and gives up its heat to the water. The water thus becomes heated at a rate dependent upon the rate and pressure of the steam discharge. As the temperature of the water approaches the boiling point the steam ceases condensing in the water but rises through the water and collects in the chamber space above it. At about the boiling point of water, or a trifle above, the pressure develops in this upper space and gradually forces the sewage up and out through effluent pipe A.

As the liquid discharges the water level and the float descend. The steam, however, remains turned on full until the float arm engages pin J, when a slight further descent shuts off the steam. The level of liquid at which the steam is shut off and at which discharge from the tank immediately ceases may be predetermined by the position of the pin J. The small hole H is provided to enable the air in the tank to escape as the sewage enters. The relation of the size of this hole to the total cross-section areas of the steam influent openings is such that only a very small percentage of the steam entering through pipe F can escape through hole H, and therefore pressure develops in the tank practically as fast as if hole H were not present. This hole may be replaced by a simple thermovalve, which will be open below say, 80° C. and closed above that temperature, but the percentage of steam escaping through H is so low that it is doubtful whether the inclusion of such a valve is warranted.

Experimental.

A device similar to the above has been operated by the writer in the basement of the Hygienic Laboratory in Washington, D. C. A number of tests made with tap water demonstrated that the device worked entirely satisfactorily so far as its mechanical operation is concerned. A test was also made to determine the mechanical and germicidal effect of the action of the device upon human wastes. The device was used six times as a toilet and then operated. The effluent seemed to be almost homogeneous, the lumps of fecal matter and the pieces of toilet paper having apparently been macerated by the violence of the steam action into very small bits. It was apparent that most of the fecal matter was actually dissolved in the water and samples collected in bottles appeared at first sight to be simply a yellowish liquid until closer inspection revealed a small amount of fine, suspended matters. Bacterial samples were collected and tested for total bacteria and for *B. coli*. The results of these tests showed a total count of 11 bacteria per c. c. and a total absence of *B. coli* in 100 c. c. The 11 bacteria which did develop were probably spore formers, which are not always killed by a single subjection to the influence of heat. However, intestinal bacteria pathogenic via the

intestinal tract are not spore formers. The liquid in the disinfector was much stronger than ordinary municipal sewage. Mr. George A. Johnson, in a sewage report for the city of Columbus, gives the number of *B. coli* for the local sewage as an average of about 500,000 per c. c. The total number of bacteria per c. c. in municipal sewage is always over a million. The above tests and facts therefore indicate that the germicidal efficiency of the device is practically 100 per cent and the disinfection efficiency actually 100 per cent. A series of experiments will be made to confirm these results.

Application.

The above device may be used wherever it is desired to heat to 100° C. and discharge automatically any liquid which is received intermittently or continuously. The device is not limited to the use of steam as heating agent. For the steam may be substituted electric heating elements; a coil of pipe carrying the exhaust from a gasoline engine; direct heat from gas or gasoline burners, equipped if desired with pilots, etc.

The device will therefore apply in particular to the disinfection of sewage or toilet wastes from steamers or from steam, electric, or gasoline railway trains. The container need not be over 12 to 15 inches high, 12 to 15 inches wide, and 4 feet long, and may therefore easily be suspended under the end platforms of the coaches laterally across the coach. The toilets are always at the ends of the coaches, and this makes the necessary length of additional pipe from the toilet to the container not over several feet. The equipment of railway coaches with this device would make it possible to keep the toilet unlocked at all times, instead of being locked at railway stations and while passing over watersheds for drinking water. The inconvenience of this latter practice has become impressed upon every traveler. The disinfection of train sewage before discharge would also afford a higher degree of insurance against the infection of city water supplies. It is true that if the control were absolute the locking of toilet doors while passing over watersheds would prevent the infection of those watersheds, but it is doubtful that the control can be absolute. Such a control would mean the insurance that every toilet on every train be locked while passing over every drinking-water area; and the writer has personally observed an unlocked toilet while passing over the Seattle watershed.

It would be advisable that the steam supply to the device be closed while the train is standing in a passenger station to avoid the discharge of the contents at that time. The steam-supply valve stem can be made to penetrate the car floor external to the toilet room, and thus cause no more inconvenience in its operation than the

present locking of the toilet doors. The disinfector would have a sufficient reserve capacity to care for the period of standing in stations. If the device be in the act of discharging as the station is approached, the mere shutting off of the steam will at once discontinue the action. Discharge will also cease immediately if the toilet be flushed and not begin again until the added material has been brought to the boiling point.

Cost.

Preliminary cost studies indicate that the construction of the disinfector should not cost much over $2 per cubic foot capacity, noninstalled. The installation cost will vary with the conditions of installation. The capacity of the disinfector for steamers should be about one hour's flow during the hour of maximum usage. The capacity for railway trains may probably reasonably be placed at three to four hours' flow. It is estimated that the flow from one steamer closet during the maximum hour of usage will not exceed 8 cubic feet. This, with the above-estimated capacity cost, makes the uninstalled construction cost per closet about $16. The two closets on a railway coach will probably not discharge more than 2 cubic feet in the maximum hour, or in four hours 8 cubic feet. The uninstalled construction cost per railway coach will therefore probably be from $15 to $20.

Preliminary studies of the cost of operation indicate that with steam as heating agent the disinfection of one steamer closet flush will cost $0.001, or $1 per thousand closet flushes. On the same basis the disinfection of one railway coach closet flush would cost about $0.000075, or 7½ cents per thousand flushes. Therefore, if each steamer closet discharges on the average 50 times every day, the cost of disinfection per day per closet on steamers will be 5 cents. If each railway coach toilet discharges 100 times every day, the cost of sewage disinfection per coach per day will probably not be over 1½ cents. It is believed that these assumptions of toilet usage are, if anything, excessive, and that the actual average annual cost of steam disinfection would be considerably less than 365 times the above daily estimates.

Further experiments are being made upon the steam disinfector for confirmatory results, and these experiments will be discussed when they are completed.